Master Thesis U.S.E.

An Analysis of the ECB's Response with Interest Rate Policy Tools During Crisis Periods Over the Past 20 Years and Its Economic Implications

Ozan Özkurt
7751486

Program: Financial Management

Supervisor: Solomon George Zori

Co-reader: Jan Renaud

June 2024

ABSTRACT

This research study aims at identifying the crisis periods in the Euro zone by using the major deviations from the ECB's inflation target and seeing whether the ECB's interventions using the interest rate instrument in different crisis periods were successful in achieving the ECB's target inflation rate of 2% in four different crisis periods with different dynamics. For more accurate results, we use all 20 eurozone countries and their quarterly data. We collected ECB interest rates and inflation data for each eurozone country between 2004 and 2023. To test our hypothesis, we conducted empirical analysis using a panel data regression model. First and foremost, we detect four different crisis periods by using the major deviations from the ECB's inflation target, which are the 2008 global financial crisis, the 2011 European debt crisis, the 2019 COVID-19 crisis, and the 2022 energy crisis following Russia's invasion of Ukraine. Secondly, we benefited from data before the effects of the crisis emerged, data during the crisis processes, and data during the period when the effects of the crisis started to disappear.

Keywords: ECB, interest rates, inflation, target inflation, eurozone, crisis

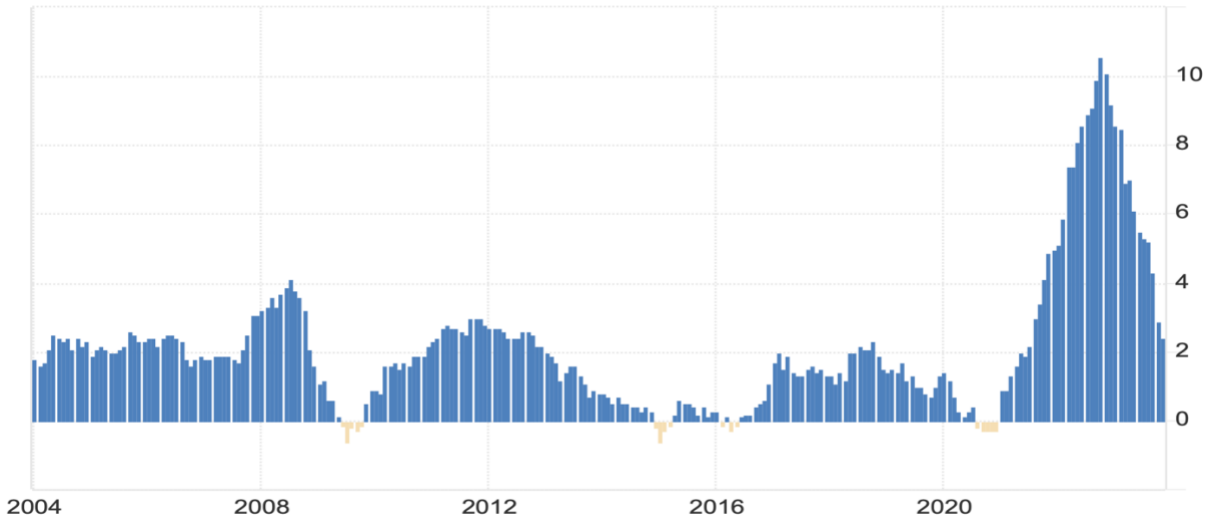
TABLE OF CONTENT

1. INTRODUCTION

The European Central Bank (ECB) was established on June 1, 1998, to support the transition to a single currency, the Euro, and preserve its value. The main purposes of the ECB's work are to preserve price stability and uphold the economic policies of the European Union. The European Central Bank and the other national central banks act together in the euro area to reach their stabilization goals. Price stability is one of the most important requirements, and the ECB uses monetary policy to ensure that it is the best way to support economic growth and employment. They are trying to keep inflation low, stable, and predictable. The ECB's target inflation rate is 2% over the medium term, and since low inflation, like high inflation, has negative effects, the ECB monitors this situation as long as inflation is above or below this target and intervenes with monetary policy instruments if necessary.

To keep the price stable, the ECB has more than one monetary policy instrument, but we focused on interest rate policy tools in this research to understand if the effects of changing interest rates during crisis terms have a positive effect on reaching or maintaining the inflation target set by the ECB. There are a lot of ways to define crises, such as negative GDP growth or rapid chancing in asset prices, but we considered extreme deviations from the target inflation rate as a crisis period because the main goal of our thesis is to test the effect of ECB intervention by using an interest rate tool on inflation to keep the inflation rate close to the inflation goal set by the ECB. According to this approach, we can say that the ECB has faced 4 major crises in the last 20 years.

Table 1: Eurozone Inflation Between 2004 and 2023



Source: https://tradingeconomics.com

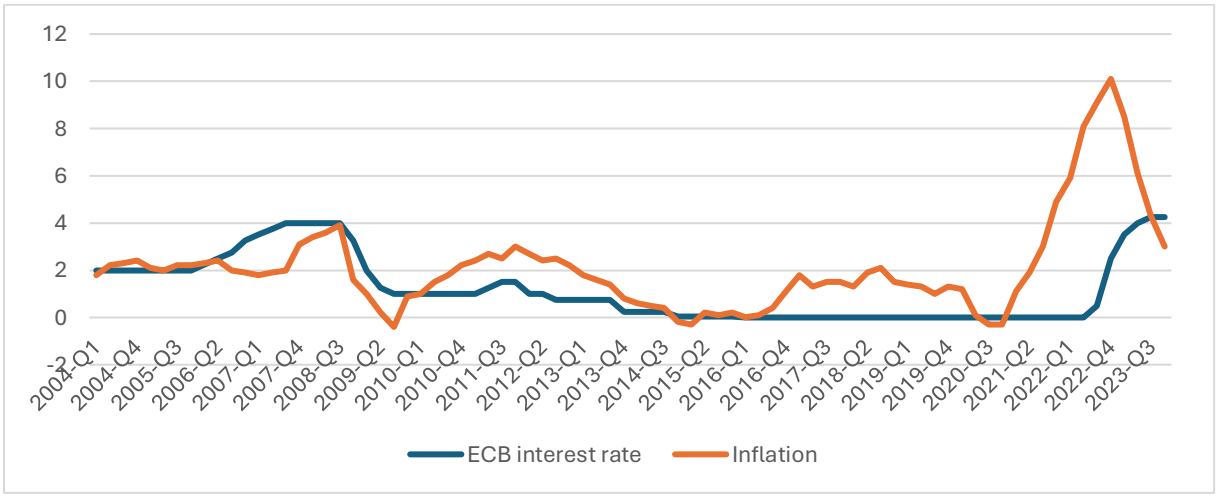
As can be seen from the graph in Table 1, during the 2008 global financial crisis, the European debt crisis, and the COVID-19 crises, eurozone inflation rates experienced sudden and large declines, while they rose much faster and sharply during the energy crisis following the Russian invasion of Ukraine. Table 2 below shows the changes that the European Central Bank made in interest rates to respond to these deviations from inflation targets.

Table 2: ECB Key Interest Rates Between 2004 and 2023

Source: https://tradingeconomics.com

When we analyze the graph in Table 2, it is seen that the ECB gradually cut interest rates in response to the falling inflation rate during the 2008 global financial crisis and the European debt crisis; during the COVID-19 crisis, no change was made since the interest rate was already zero; and finally, during the energy crisis, interest rates were gradually and sharply increased in the face of record-high inflation.

Table 3: ECB Interest Rate and Inflation Between 2004 and 2023



As can be seen more clearly in Table 3, the ECB raised interest rates during periods of rising inflation, which led to a downward movement in inflation, while the ECB kept interest rates close to zero during periods of low inflation.

Crises can be defined as events that occur suddenly and can have serious consequences if not intervened, and whose effects can be short- and long-lasting, as well as possible to be experienced again over time. Financial crises can be defined as crises that have negative consequences for countries' production capacity, labor market, and inflation targets. (Fumagalli & Mezzadra, 2012). An economic crisis can be defined as a sudden and severe negative impact on a country's or region's economic performance in general. Such crises are usually characterized by high unemployment rates, low production and low demand, deviation from inflation targets, an increase in debt burden, and general economic stagnation. Economic crises can be caused by a variety of factors, such as demand- or supply-side shocks, improper fiscal and monetary policies, disruptions in international trade, and political instability. (Gorton, 2018) A banking crisis can be defined as a situation in which part or all of the banking sector experiences financial problems. During these crises, bank failure, bankruptcy, or the need for government intervention are among the expected outcomes. During these crisis periods, the negative effects include difficulty accessing loans, sudden declines in asset prices, and a loss of confidence. (Reinhart & Rogoff, 2009)

There are a lot of ways to detect cirisis used by central banks. Macroeconomic indicators such as GDP growth, unemployment, and inflation, or financial market indicators such as credit spreads, are used as tools to detect crises. Also, closely monitoring indicators like banking sector health, financial stability indicators, debt levels, and consumer confidence indexes are frequently used by central banks to detect crises. Thanks to these measurement methods, central banks can foresee a possible crisis and take action beforehand to prevent the negative effects on the economy.

In our study, we defined periods of large deviations from the 2% inflation target set by the ECB as crisis periods. Considering that it is difficult to make a clear distinction between economic crises and financial crises, that crises that start as financial crises can turn into economic crises by affecting the entire economy, and that significant deviations from the inflation target, which we have chosen as the method of crisis detection, can occur during both

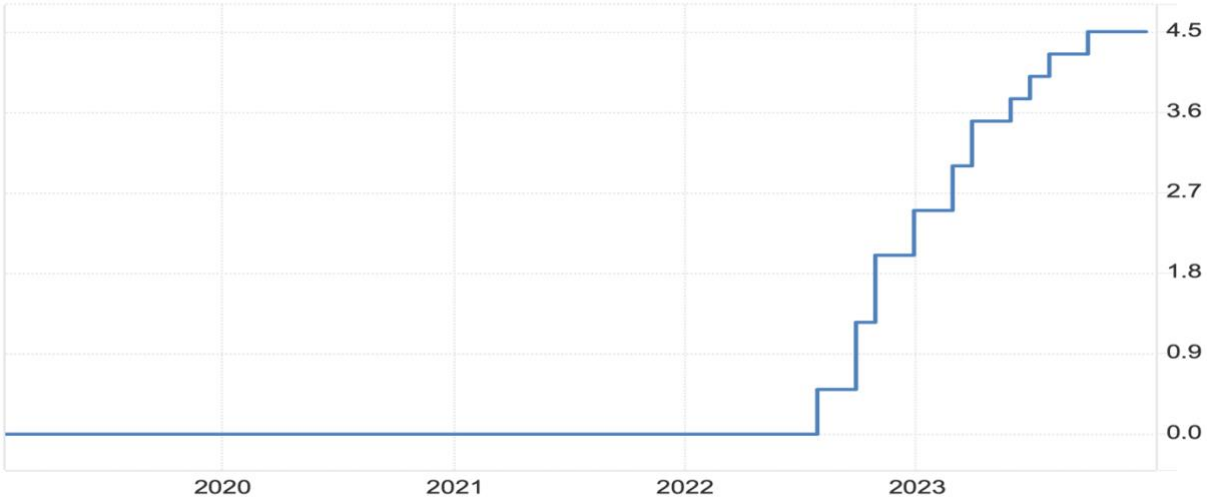
financial and economic crises, we can say that from now on, when we mention the term crisis in our study, we will refer to these two types of crises.

The first crisis we will discuss is the 2008 mortgage crisis. This crisis, which we will discuss in more detail later, can be summarized as the collapse of the mortgage market as a result of low interest rates in the United States increasing the appetite for borrowing, banks and other financial institutions failing to assess risks properly, subprime mortgage loans being granted to low-income people, credit rating agencies making erroneous assessments, resulting in the depreciation of securities traded in financial markets and problems in the repayment of loans, and then this effect spread and turned into a financial crisis affecting the whole world (Taylor, 2009). In order to alleviate the effects of this crisis and revitalize the markets, the ECB quickly cut interest rates and implemented a loose monetary policy. In the months that followed, interest rates continued to fall, resulting in an unprecedented 325 basis points cut in interest rates between October 2008 and May 2009 to 1% (ECB, 2010), which kept them at this level for a long time. It also implemented various expansionary policies, such as asset purchases.

The second crisis we will address is the European debt crisis. One of the main causes of the sovereign debt crisis in Europe is the combination of accumulated excessive debt stocks in some euro area countries and structural weaknesses in monetary and regulatory provisions in the euro area. This raised questions about the solvency of some countries at the height of the crisis, and then the ECB took various measures to deal with the critical situation that emerged (Beirne & Fratzscher, 2013). These measures included programs such as long-term bond purchases (LTRO) and OMT (outright monetary transactions), but the ECB also further reduced interest rates, which had been on a downward trend after the 2008 crisis, and adopted a negative interest rate policy (Hartmann & Smets, 2018).

The third one is a pandemic, whose name is COVID-19. The pandemic, which started in 2019 in Wuhan, China, and became a global crisis in 2020, caused the ECB to reshape its policies. Because, at that time, the ECB policy rate was already zero, as we can see in Table 2, and there was disinflationary pressure on European economies, the ECB had no chance to decrease the interest rate to boost the economy and increase inflation. Hence, the ECB took a series of emergency measures to support the economy, revitalize markets, and ensure financial stability. These measures include expanding asset purchases and providing liquidity.

Table 4: ECB Key Interest Rates Between Just Before and After Covid-19 Term



Source: https://tradingeconomics.com

In these three crises, which emerged for different reasons, the ECB's interventions were similar, except that it could not use the interest rate instrument during the COVID-19 crisis and aimed to maintain price stability and support economic growth by pursuing a loose monetary policy.

The last one is the 2022 energy crisis due to the Russian-Ukrainian war. EU countries experienced energy and inflation crises together in 2022. The war between Russia and Ukraine first disrupted the foreign trade activities of Ukraine, one of the world's largest grain exporters, and Russia, one of the world's largest energy exporters, and caused problems in the supply chain. Given that the European region is partly energy dependent, the sharp rise in energy prices, especially since the first months of 2022, inevitably led to an increase in inflation rates, budget deficits, and public debt (Taskovski & Paceskoski, 2023). As a result of this, inflation in Europe has risen just over 10%, which is way more than the European Central Bank's (ECB) general target of 2 percent. As a result, the European Central Bank has tightened its monetary policy and raised interest rates significantly, above 4%, in order to reduce inflation and stabilize markets (Niinimäki & Välimäki, 2023).

First of all, this study analyzes four different crisis periods identified by utilizing the major deviations from the ECB's inflation target to determine the effects of the ECB's interventions using the interest rate instrument in each crisis period separately. Our goal is to see whether the ECB's interventions using the interest rate instrument in different crisis periods were successful in achieving the ECB's target inflation rate of 2% in four different crisis periods

with different dynamics. The data required for this empirical analysis are obtained from the World Bank, IMF, and ECB databases, and then the panel data regression analysis method is used to analyze the data.

The contribution of this study to the literature is to provide an overview of the crisis periods of the last 20 years through the changes in the ECB's interest rates and to provide a comparative analysis by examining the effectiveness of the interest rate tool in four different crisis periods for all eurozone countries, taking into account that each crisis has different internal dynamics.

To summarize this study in general, the following sections will include the literature review and review of similar studies in the second section; research design and metadology will be introduced in the third section; emprical results and analysis we will use in the fourth section; and our conclusions will be in the fifth and last sections, respectively.

2. LITERATURE REVIEW

2.1 ECB Monetary Policy Tools

Although traditional monetary policy instruments include open market operations and setting reserve requirements, the interest rate is usually the most commonly used traditional monetary policy instrument by central banks. The ECB uses these instruments for various policy objectives, such as controlling inflation, supporting economic growth, and stabilizing financial markets. However, modern economics has recognized that sometimes these methods are insufficient to support economies in crisis. Even if lowering interest rates has a positive effect on stimulating the economy up to a certain point, once the zero lower bound is reached, other instruments can be required. This is where unconventional monetary policy methods come into play (Pronobis, 2014).

The main unconventional monetary policy tools include asset purchases such as quantitative easing and credit easing, liquidity operations, negative interest rates, and the ECB's communication tools. All these instruments can be used by the ECB to support conventional monetary policy when necessary, in line with the desired objective. The common characteristic of all these instruments is that they are usually used as supportive tools after the interest rate has hit the zero lower bound (Blot, Creel, and Hubert, 2017).

2.2 ECB interest rate policy againts the 2008 global crisis,

On September 15, 2008, the bankruptcy of Lehman Brothers, one of the largest investment bank in the United States, and the failure of the US government to take any action to rescue Lehman Brothers led to serious insecurity and uncertainty in the financial markets. This collapse can be considered one of the turning points of the financial crisis. In a very short period of time, this effect turned into a financial crisis that first affected the United States and then the whole world.

In light of these developments, many central banks around the world were forced to take swift action against this crisis. As a result of the downward inflationary pressure in the markets, the ECB cut interest rates by 50 basis points in the first stage and by 325 basis points in total between October 2008 and May 2009, bringing them down to 1 percent, the historical low point until then (Trichet, 2010).

However, although the ECB changed its monetary policy between 2007 and 2008, it is possible to say that it acted significantly later than the FED in terms of intervention against this crisis and interest rate cuts (Morelli & Seghezza, 2021).

In addition, the ECB has also introduced a number of unconventional fiscal policy instruments as support. These instruments include the introduction of fixed-rate refinancing auctions, the provision of large amounts of cash to banks at low interest rates, and bond purchases, including mortgages and debt securities (Hodson & Quaglıa, 2009).

2.3 ECB intervention againts the 2011 European debt crisis

According to Hobelsberger, Kok Sørensen, and Mongelli (2022), "concerns about high public debt, which first emerged in Greece in 2009, spread to other European countries such as Cyprus, Italy, Ireland, Spain, and Portugal in 2010, raising serious questions about the sustainability of public debt. To mitigate the effects of the crisis, the ECB cut its policy rate to historic lows. It also supported its policy with other instruments, such as bond purchases and providing liquidity to banks. In July 2012, Mario Dragi, then president of the central bank, announced that they would take all necessary measures to preserve the value of the euro, sending a message to the markets that they were determined and using the communication channel as a policy tool."

Research conducted by Pavlík (2012) suggests that in order to mitigate the effects of global financial crisis and to alleviate the effects of the economic stagnation in European countries, the ECB first decided to reduce the key interest rate from 4.25% to 3.75% during the interest rate cut process initiated on October 15, 2008, and this downward process continued until the historic low of 1.0% on May 1, 2009. After this date, anticipating that the effects of the crisis had diminished, the ECB took a step towards a return to normal monetary policy by raising interest rates and, in order to alleviate inflationary pressures, raised the key interest rate to 1.25% in April 2011. Then, on July 6, 2011, it raised the key interest rate again to 1.50. However, after the negative outlook for economic growth expectations and growing concerns about high public debt in many European countries, on November 3, 2011, the Bank decided to cut interest rates to 1.25% and finally to 1.00% in December 2011, a historic low.

2.4 ECB intervention in the COVID-19 crisis

According to Jacob, Christopher, and William (2021), Generally, the most common move of central banks in times of crisis can be expressed as lowering the policy rate to eliminate stagnation in financial markets and stimulate the economy. The central bank tried to implement a similar policy against the COVID-19 crisis. A low interest rate makes it easier to access credit and, as a result, leads to an increase in asset prices as cash becomes easier to access. However, in February 2020, at the height of the impact of the COVID-19 pandemic on financial markets, Europe was characterized by low inflation and low growth rates, and the ECB's policy rate was at very low levels. Therefore, the ECB did not have enough room for intervention to effectively use an important traditional monetary policy tool such as the policy rate.

"In the study by Aguilar, Arce, Hurtado, Martínez-Martín, Nuño & Thomas (2020), it was said that, in the pre-Covid-19 period, disinflationary pressures and the fight against low inflation continued in Europe. This meant that the ECB had to keep its policy rate at historically low levels (close to zero). As the policy rate was already close to the zero lower bound, the ECB was unable to cut the policy rate further and started to rely on some unconventional monetary policy tools. Among the unconventional monetary policy tools that the ECB used in this period, it is possible to mention instruments such as asset purchase programs and long-term refinancing operations. The reasons for the ECB's additional use of unconventional monetary policy tools are to support monetary policy and the stability of financial markets and to provide liquidity to banks to keep credit flowing and keep markets buoyant. In addition, we can say that the ECB reacted to the COVID-19 crisis much faster than in past crises.

2.5 ECB intervention againts the 2022 energy crisis due to Russian-Ukrainian war

According to Benigno, Canofari, Di Bartolomeo, and Messori (2023), in February 2022, Russia's invasion of Ukraine led to disruptions in financial markets due to the supply side of international trade. The prolongation of the invasion led to a significant increase in energy prices, especially in European countries with high energy dependence on Russian natural resources, which triggered an upward spike in inflation. In July 2022, the Fed raised the policy rate by 50 and 75 basis points to 2.5%. With this process, the period of low inflation in Europe since 2007 with an average of 1.6% points and the zero lower bound period that lasted from 2014 until the rate hike in July 2022 came to an end.

Orphanides & Reichlin (2023) and ECB Monetary Policy Decisions (2023), In 2022, with Russia's invasion of Ukraine, the rise in energy and food prices in Europe due to problems in supply chains reached its peak with the effect of the sanctions imposed on Russia in the following periods, and the European Central Bank had to increase interest rates to bring the rising inflation to the target level of 2%. Inflation, which was 5.9% in February 2022, reached a record high of 10% in September of the same year. In the face of these developments, the ECB raised its policy rate by 50 basis points, which it had not increased for more than 10 years, and this increase in July 2022 was the largest rate hike since 2007. In 2023, the ECB continued to increase interest rates with determination, raising the policy rate to 4.5%, and as a result, inflation fell to 2.4% by the end of 2023.

The aim of this study is to see whether the ECB's interventions using the interest rate instrument in different crisis periods were successful in achieving the ECB's target inflation rate of 2% in four different crisis periods with different dynamics in the eurozone area.

We selected financial data and indicators from all 20 eurozone countries between 2004 and 2023 using the quantitative research approach. Stata 16.1 was used to do panel data regressions to examine all of this information.

We determined four different crisis periods by using the major deviations from the ECB's inflation target, which are the 2008 financial crisis, the 2011 European debt crisis, the 2019 COVID-19 crisis, and the 2022 energy crisis due to the Russian-Ukrainian war, and then we tested if the ECB's interventions using the interest rate instrument in different crisis periods were successful in achieving the ECB's target inflation rate of 2% in 4 different crisis periods. Additionally, since it may take time to see the effects of the increase in interest rate and money supply on inflation, we added a lag of 2 quarters to the money supply and ECB interest rate variables to make their effects on inflation more accurate.

Although there is no study in the literature that tests the effectiveness of interest rate policy alone in achieving the inflation target, in general, considering all these issues mentioned in the literature review section and considering that the interest rates of the European Central Bank were already close to zero in most of the years covered by our study, therefore do not have much room for maneuver and since the crises we have identified in our study are complex crises

with multiple causes, we believe that an intervention with interest rates alone will not be effective and we make the hypotheses listed below.

(H1) The European Central Bank's interventions using the interest rate instrument during the 2008 financial crisis did not have a positive and significant effect on the ECB's achievement of its inflation target.

(H2) The European Central Bank's interventions using the interest rate instrument during the European debt crisis did not have a positive and significant effect on the ECB's achievement of its inflation target.

(H3) The European Central Bank's interventions using the interest rate instrument during the COVID-19 crisis did not have a positive and significant effect on the ECB's achievement of its inflation target.

(H4) The European Central Bank's interventions using the interest rate instrument during the energy crisis do not have a positive and significant effect on the ECB's achievement of its inflation target.

3. RESEARCH DESIGN AND METADOLOGY

3.1 Sample

In order to measure, analyze, and interpret the effects of the European Central Bank's use of the interest rate instrument on inflation in different crisis periods, data was collected from various reliable sources. We collected the ECB's interest rate data by using the ECB's website. We benefited from the Woldbank and IMF data bases to get population, money supply, unemployment, inflation, and GDP per capita data for all eurozone countries.

3.2 Variables

Table 5 below provides an overview of the definitions of the variables to be used in the regression model.

Table 5: Defination of Variables That Used in Our Research

Variable	**Type of Variable**	**Defination**
Inflation	Dependent	Inflation rate for all eurozone countries between 2004 and 2023.
ECB Interest Rate lag 2	Independent	Two quarters lagged ECB interest rates for all eurozone countries between 2004 and 2023.
GDP per capita	Control	GDP of all eurozone countries between 2004 and 2023
Population	Control	Population of all eurozone countries between 2004 and 2023
Money Supply lag 2	Control	Two quarters lagged money supply for all Eurozone countries between 2004 and 2023.
Unemployment Rate	Control	Unemployment rate of all eurozone countries between 2004 and 2023

Inflation: Since our main objective is to measure the impact of the ECB's interest rate policy on the convergence to the inflation target, inflation is defined as the dependent variable. This can be defined as the percentage change in the consumer price index of the countries we have identified within the scope of our study over a specified time period.

ECB Interest Rate Lag2: Since we are trying to understand the impact of the ECB's interest rate movements on inflation, the ECB interest rate is set as an independent variable. By

changing this rate, the ECB can have an impact on borrowing costs, economic activity, and inflation. Also, we added a two-quarters lag to see the effect on inflation clearly.

GDP per capita: We added GDP per capita as a control variable, and this variable represents the gross domestic product per capita of eurozone countries at the time between 2004 and 2023.

Population: Population is another control variable that represents the population of all eurozone countries. It can have different types of effects on inflation.

Money Supply Lag2: We added the money supply amount for all eurozone countries as a control variable because it represents the total amount of money in the economy and can have a potential effect on inflation rates. Also, we added a two-quarters lag to see the effect on inflation clearly.

Unemployment Rate: This is another control variable, and it represents the average annual unemployment rate of all eurozone countries. We can say that it is the percentage of the labor force that is actively seeking employment but unable to find it. Higher unemployment rates can sometimes be associated with lower inflation due to reduced consumer demand and pressure.

3.3 Regression Model

To test our four different hypotheses, we will use a regression model, which is given below. Although we are testing whether the ECB's use of the interest rate instrument has a positive and significant effect on achieving the targeted inflation rate, we would like to test how inflation is affected by other variables by adding variables other than the interest rate to the regression and to better analyze the impact of the ECB's interventions by adding country-specific characteristics. We aimed to isolate the effects of the ECB's interest rate instrument by trying to measure the impact of other variables, to determine whether the change in inflation is really due to these interest rate movements, and to strengthen the robustness of the regression model by reducing the possibility of omitted variable bias.

$$Inflation_{it}=\beta 0+\beta 1 ECBinterest_{i,(t-2)}+\beta 2 Moneysupply_{i,(t-2)}+\beta 3 Population_{i,t}+\beta 4 GDPpercapita_{i,t}+\beta 5 Unemployment_{i,t}+\epsilon_{i,t}$$

The regression model can be summarized below;

$Yit = \beta 0 + \beta X_{it} + \boldsymbol{\varepsilon}_{it}$

Where;

Y = dependent variable

β0 = Constant term

X = Independent / Control variables

$\boldsymbol{\varepsilon}$ = Error term

i = countries (all 20 eurozone countries)

t = time period (2004 - 2023)

4. EMPRICAL RESULTS AND ANALYSIS

In this section of the thesis, empirical analyses of the data we have obtained are tested, and it is aimed at interpreting and discussing the outputs obtained as a result of these analyses. As mentioned in the Introduction section, 4 different crisis periods were identified by using the major deviations from the ECB's inflation target and 4 different hypotheses were tested in order to determine the effects of the ECB's interventions using the interest rate instrument in each crisis period separately. In our first hypothesis during the 2008 global financial crisis (2007–2011), in our second hypothesis during the European debt crisis (2011–2014), in our third hypothesis during the economic crisis caused by the COVID-19 pandemic (2018–2021), and finally during the energy crisis (2021–2023), which is one of the main reasons for the increase in energy prices that hit Europe as a result of the Russian invasion of Ukraine, we tried to determine whether the ECB's interventions using the interest rate to minimize the effects of these crises are effective in achieving the ECB's target inflation. In order to better observe the consequences of crisis effects on financial markets, in addition to ECB interest rates and inflation data, previous studies were also analyzed, and optimum date ranges were selected. In these date ranges, data before the effects of the crisis emerged, data during the crisis processes, and data during the period when the effects of the crisis started to disappear were used. Some data was already in quarterly format, but to bring ECB interest rates to quarterly status, we used the average of three consecutive months of data. This study will provide us with a broad perspective to see whether the ECB's interventions using the interest rate instrument in different crisis periods were successful in achieving the ECB's target inflation rate of 2% in four different crisis periods with different dynamics.

4.1 An Emprical Analysis of the 2008 Financial Crisis

Table 6: Summary Statistics of The Variables Used For The 2008 Global Financial Crisis Period

Variable	Obs	Mean	Std. Dev.	Min	Max
Inflation	320	2,641759	2,913499	-3,87	17,53
ECBinterestlag2	320	2,762094	1,2839	1	4,23
Moneysupplylag2	320	8800763	664600,7	7484128	9433688
Population	320	1.69e+07	2,39e+07	404500	8,11e+07
GDPpercapita	320	33801,41	15010,62	16344,6	92205
Unemployment	320	8,763625	4,158749	3,7	20,63

This table gives a basic summary of our dependent and independent variables, which were used to test the effects of ECB interest rates on inflation in the 2008 global financial crisis. We used all 20 eurozone countries and quarterly data between 2007 and 2011, so we have 320

observations for all our variables. According to the table, our dependent variable inflation has a 2,641759 mean value, which is slightly higher than the inflation target of the ECB, and a 2,913499 standard deviation. Minimum values and maximum values are -3,87 and 17,53 respectively, for the inflation in this period. We can see that inflation took negative values in this period due to the impact of the crisis. ECBinterestlag2 has 2,762094 mean value and 1,2839 standart deviation. Minimum values and maximum values are 1 and 4,23 respectively, for the ECBinterestlag2 in this period. This shows that the ECB used a wide range of interest rate tools during this period. Moneysupplylag2 has an 8800763 mean value and 664600,7 standard deviation. Minimum values and maximum values are 7484128 and 9433688 respectively, for the Moneysupplylag2 in this period. The population has 16,9 million mean values and 23,9 million standard deviations. For the population during this period, the minimum and maximum values are 404500 and 81,1 million, respectively. It demonstrates a significant difference in population between the eurozone's smallest and largest countries. GDPpercapita has a 33801,41 mean value and a 15010,62 standard deviation. Minimum values and maximum values are 16344,6 and 92205 respectively, for the GDPpercapita in this period. We can say that there is a big gap between the eurozone countries in terms of their wealth conditions. Unemployment has an 8.763625 mean value and 4,158749 standard deviation. Minimum values and maximum values are 3,7 and 20,63 respectively, for unemployment in this period. This indicates a significant disparity between their respective job markets.

Table 7: Pairwise Correlation Matrix For 2008 Global Financial Crisis Period

	ECBinterest lag2	**Moneysupply lag2**	**Population**	**GDP percapita**	**Unemploy-ment**
ECBinterestlag2	1				
Moneysupplylag2	-0,5237	1			
Population	-0,0015	0,0028	1		
GDPpercapita	0,0005	0,0191	0,0610	1	
Unemployment	-0,3988	0,3670	0,0136	-0,4103	1

The table that is given above shows an interactive correlation between the independent variables used in our model. According to this matrix, there is no strong correlation that is bigger than 0,7 or smaller than -0,7. The strongest correlation has a -0.5237 coefficient between ECBinterestlag2 and Moneysupplylag2, but it is still smaller than 0.7, so it does not count as a strong correlation. Most other correlations among the independent variables are weak or negligible.

Table 8: Hausman Test For The 2008 Global Financial Crisis Period

Hausman test	
	Coef.
Chi-square test value	13.40
P – value	0.0038

In deciding whether fixed effects or random effects is better suited for our panel data study, we applied the Hausman test. According to the test results, the chi-square value of 13.40, combined with a p-value of 0.0038, strongly indicates that the fixed effects model is more appropriate for our models. This means that the difference between the fixed effects model and the random effects model is statistically significant, and the fixed effects model should be preferred. In other words, the unique errors are correlated with the regressors, and the fixed effects model will provide more reliable and consistent estimates.

Table 9: Panel Regression Results of The 2008 Global Crisis Period

VARIABLES	(1) Inflation
ECBinterestlag2	0.382***
	(0.0930)
Moneysupplylag2	-3.10e-07
	(1.97e-07)
Population	2.57e-06***
	(5.25e-07)
GDPpercapita	0.000535***
	(8.93e-05)
Unemployment	-0.476***
	(0.0490)
Constant	-52.93***
	(8.985)
Observations	320
Number of country numeric	20
R-squared	0.605

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The table that is given above includes the regression results of the 2008 global financial crisis, which were calculated using the fixed effects regression model. The main target of this test is to discover the effects of ECB interest rate changes on inflation in the eurozone area, which is mentioned in Hypothesis 1. We consider all 20 Eurozone countries and use 16 consecutive quarters as the time period; therefore, we have 320 observations in total. We are trying to measure the effects of the ECB interest rate on inflation, so variability between

countries is not important, which means that the important R-sq value is within R-sq value for us. Our within R-sq value is 0.6050 which means that 60.5% of the variability in the dependent variable (inflation) within each country is explained by the model. According to the their p-values, our independent variables ECBinterestlag2, population, GDPpercapita and unemployment are statistically significant at the 5% level; however, Moneysupplylag 2 is not statistically significant at the 5% and 10% levels. Unemployment has a negative coefficient of -.4757047, which shows a negative correlation between inflation and unemployment. A one-unit increase in unemployment is associated with a 0.4757 decrease in inflation. Population and GDPpercapita have a positive coefficient of 2.57 and .0005347 respectively, which indicates a positive correlation between these two independent variables and inflation. Lastly, ECBinterestlag2 has a positive coefficient of .3819272 which means that a one-unit increase in ECB interest rates lagged by two periods is associated with a 0.3819 increase in inflation, holding other variables constant. This relationship is statistically significant ($p = 0.000$). Under normal conditions, we expect an inverse relationship between inflation and the ECB's main refinancing operation rate, as when inflation increases, central banks generally raise interest rates to limit money supply and reduce demand. This process aims to control inflation. Similarly, when inflation falls, central banks lower interest rates to increase demand and avoid deflation. These policies create an inverse negative relationship between inflation and interest rates. But in our case, there is a small but positive coefficient. We have added a 2-quarter lag to see the effect of interest rate changes on inflation. If we had used just one quarter lag, the interest rate would have been 0.63077 which is bigger than the coefficient of ECB interestlag2 (0.3819272). If we use a 4-quarter lag, then the coefficient turns negative but becomes insignificant. When we examine both inflation and the ECB interest rate between 2007 and 2011, and when we take into account the decline in the coefficient of this variable as the lag time increases, it is possible to say that the ECB's lowering of the interest rate in order to intervene in inflation, which fell below the target inflation level due to the crisis, slowed down the rate of decline and brought it closer to the target inflation level in the long run, even if it did not succeed in increasing inflation at first.

Table 10: Inflation in Eurozone Countries Between 2007-2011

Countries	INFLATION BEFORE FIRST ECB INTERVENTION (2008-Q3)	INFLATION AFTER LAST ECB INTERVENTION (2009-Q3)	MAX INFLATION (2007-2011)	MIN INFLATION (2007-2011)	DIFFERENCE BETWEEN INFLATION BEFORE AND AFTER THE INTERVENTION
FRANCE	3,6	-0,47	3,7	-0,47	4,07
GERMANY	3,23	-0,37	3,23	-0,37	3,6
ITALY	4,1	0,1	4,1	0,1	4
NETHERLANDS	2,9	-0,07	3,13	-0,07	2,97
SPAIN	4,93	-0,97	4,93	-0,97	5,9
AUSTRIA	3,7	0,6	3,8	-0,07	3,1
BELGIUM	5,6	-1,13	5,6	-1,13	6,73
CROATIA	7,1	1,2	7,1	0,77	5,9
CYPRUS	5,13	-0,97	5,13	-0,97	6,1
ESTONIA	11,03	-0,93	11,5	-2,03	11,96
FINLAND	4,53	1,2	4,53	1,2	3,33
GREECE	4,8	0,8	5,6	0,8	4
IRELAND	3,3	-2,6	3,67	-2,77	5,9
LATVIA	15,6	1,23	17,53	-3,87	14,37
LITHUANIA	11,97	2,37	12,3	-0,43	9,6
LUXEMBOURG	5,13	-0,7	5,13	-0,73	5,83
MALTA	5,3	0,87	5,3	-0,9	4,43
PORTUGAL	3,13	-1,5	3,8	-1,5	4,63
SLOVAKIA	4,5	0,37	4,67	-0,03	4,13
SLOVENIA	6,13	-0,17	6,43	-0,17	6,3

An analysis of the data in Table 10 reveals that inflation rates across the eurozone countries differ significantly from each other. For example, between 2007 and 2011, the highest inflation rates in Germany and France, the two largest economies and industrialized countries of the European Union, were 3.23 and 3.7, respectively, while the highest inflation rates in Latvia and Lithuania, the smaller economies, were 17.53 and 12.3, respectively. Over the same period, the minimum inflation rates were closer to each other. In line with these observations, since the difference between inflation before and after the intervention is higher in small-scale economies, it is possible to say that the ECB's monetary policy interventions using the interest rate instrument are more effective in small-scale economies where the inflation rate varies over a wider range.

4.2 Emprical Analysis of the European Debt Crisis

Table 11: Summary Statistics of The Variables Used For The European Debt Crisis Period

Variable	Obs	Mean	Std. Dev.	Min	Max
Inflation	320	1.904344	1.446383	-2.2	5.43
ECBinterestlag2	320	.830625	.3604328	.23	1.47
Moneysupplylag2	320	9623484	228560.2	9257340	9931489
Population	320	1.71e+07	2.42e+07	415273	8.12e+07
GDPpercapita	320	37325.11	16578.53	18285.5	108056.6
Unemployment	320	11.79838	5.793346	4.4	28.07

We used this table to test the effects of ECB interest rates on inflation during the European debt crisis, providing a basic summary of our dependent and independent variables. We use all 20 eurozone countries and quarterly data between 2011 and 2014, so we have 320 observations for all our variables. According to the table, our dependent variable inflation has a 1.904344 mean value, which is slightly lower than the inflation target of the ECB, and 1,446383 standard deviation. Minimum values and maximum values are -2.2 and 5.43 respectively, for the inflation in this period. We can see that inflation took a negative turn during this period due to the impact of the crisis. ECBinterestlag2 has a .830625 mean value and a .3604328 standard deviation. Minimum values and maximum values are .23 and 1.47 respectively, for the ECBinterestlag2 in this period. This shows that the ECB used their interest rate tools in this period in a smaller range than in the 2008 global crisis period. Moneysupplylag2 has a 9623484 mean value and 228560,2 standard deviation. Minimum values and maximum values are 9257340 and 9931489 respectively, for the Moneysupplylag2 in this period. The population has a 17.1 million mean value and 24,2 million standard deviation. Minimum values and maximum values are 415273 and 81,2 million, respectively, for the population in this period. It shows that there are very big difference between smallest and biggest countries population in the eurozone. GDPpercapita has a 37325,11 mean value and a 16578,53 standard deviation. Minimum values and maximum values are 18285,5 and 108056,6 respectively, for the GDPpercapita in this period. We can say that there is a big gap between the eurozone countries in terms of their wealth conditions. Unemployment has a 11.79838 mean value and a 5.793346 standard deviation. Minimum values and maximum values are 4.4 and 28.7 respectively, for unemployment in this period. This indicates a significant disparity between their respective job markets.

Table 12: Pairwise Correlation Matrix For The European Debt Crisis Period (2011-2014)

	ECBinterest lag2	Moneysupply lag2	Population	GDP percapita	Unemploy-ment
ECBinterestlag2	1				
Moneysupplylag2	-0.8240	1			
Population	-0.0014	0.0016	1		
GDPpercapita	-0.0680	0.0737	0.0440	1	
Unemployment	-0.0250	0.0639	-0.0349	-0.4765	1

The table that is given above shows an interactive correlation between our independent variables that are used in our model. According to this matrix, there is only one strong correlation, which is between our independent variables ECBinterestlag2 and Moneysupplylag2, with a coefficient of -0.8240. This is also predictable from a real-life perspective, as these two are the most commonly used conventional monetary policy tools of central banks and are often used together to prevent the unintended effects of crises. Most of the other independent variables have weak or negligible correlations.

Table 13: Hausman Test For The European Debt Crisis Period

Hausman test	
	Coef.
Chi-square test value	1.77
P - value	0.622

In deciding whether fixed effects or random effects is better suited for our panel data study, we applied the Hausman test. According to the test results, the chi-square value of 1.77 combined with a p-value of 0.622 strongly indicates that the difference between the fixed effects model and random effects model is not statistically significant and random effects model should be preferred based on failing to reject the null hypothesis. So we will use a random effects model to analyze the European debt crisis period.

Table 14: Panel Regression Results of The European Debt Crisis Period

VARIABLES	(1) Inflation
ECBinterestlag2	1.320***
	(0.207)
Moneysupplylag2	-2.98e-06***
	(3.33e-07)

Population	-4.49e-09
	(4.78e-09)
GDPpercapita	-2.69e-06
	(7.66e-06)
Unemployment	-0.0443**
	(0.0180)
Constant	30.22***
	(3.285)
Observations	320
Number of country numeric	20

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The table presented above shows the regression results of the European debt crisis, which were calculated by using the random effects regression model. The main target of this test is to discover the effects of ECB interest rate changes on inflation in the eurozone area, which is mentioned in Hypothesis 2. We consider all 20 Eurozone countries and use 16 consecutive quarters as the time period, therefore, we have 320 observations in total. We are trying to measure the effects of the ECB interest rate on inflation, so variability between countries is not important, which means that the important R-sq value is within R-sq value for us. Within R-sq value is 0.7067 which means that 70.67% of the variability in the dependent variable (inflation) within each country is explained by the model. The Wald Chi-square statistic of 726.74 with a p-value of 0.0000 indicates that the model is highly statistically significant, meaning that the explanatory variables jointly have a significant effect on inflation. According to their p-values, our independent variables ECBinterestlag2, Moneysupplylag2 and unemployment are statistically significant at the 5% level; however, population and GDP per capita are not statistically significant at the 5% and 10% levels. Moneysupply has a negative coefficient of -2.98 indicating that an increase in the money supply lagged by 2 periods is associated with lower inflation. We would normally expect this coefficient to be positive since an increase in the money supply would increase inflation as per the basic laws of economics. However, when we carefully analyze our data set, we observe a steady increase in the money supply between 2011-2014, despite the fact that inflation fell to negative values in some countries from time to time. This suggests that the European Central Bank did not use the money supply instrument effectively in the relevant period. Unemployment has a negative coefficient of -.044045 value which shows a negative correlation between inflation and unemployment. A one-unit increase in unemployment is correlated with a 0.044045 decrease in inflation.

Population and GDPpercapita are not statistically significant; therefore, it is not logical to interpret their coefficients for this analysis.

Lastly, ECBinterestlag2 has a positive coefficient of 1.319875 which means that a one-unit decrease in ECB interest rates lagged by two periods is associated with a 1.319875 decrease in inflation, holding other variables constant. This relationship is statistically significant (p = 0.000). Under normal conditions, we expect an inverse relationship between inflation and the ECB's main refinancing operation rate, as we explained in detail before. But in our case, there is a small but positive coefficient in our regression analysis in Table 14. We have added a 2 quarter lag to see the effect of interest rate changes on inflation. If we had used just one quarter lag, the interest rate would have a 1.655629 coefficient, which is bigger than the coefficient of ECB interestlag2 (1.319875). If we used 4 quarters, then the coefficient would become smaller, which is 0.7865562. When we examine both inflation and the ECB interest rate between 2011 and 2014 and when we take into account the decline in the coefficient of this variable as the lag time increases, it is possible to say that the ECB's lowering of the interest rate in order to intervene in inflation, which fell below the target inflation level due to the crisis, slowed down the rate of decline and brought it closer to the target inflation level in the long run, even if it did not succeed in increasing inflation at first.

Table 15: Inflation in Eurozone Countries Between 2011-2014

Countries	INFLATION BEFORE FIRST ECB INTERVENTION (2011-Q4)	INFLATION AFTER LAST ECB INTERVENTION (2014-Q4)	MAX INFLATION (2011-2014)	MIN INFLATION (2011-2014)	DIFFERENCE BETWEEN INFLATION BEFORE AND AFTER THE INTERVENTION
FRANCE	2,63	0,33	2,63	0,33	2,3
GERMANY	2,57	0,43	2,63	0,43	2,14
ITALY	3,7	0,17	3,7	-0,1	3,53
NETHERLANDS	2,63	0,2	3,3	0,2	2,43
SPAIN	2,7	-0,6	3,3	-0,6	3,3
AUSTRIA	3,67	1,23	3,8	1,23	2,44
BELGIUM	3,3	0	3,5	0	3,3
CROATIA	2,37	0,23	4,37	0,03	2,14
CYPRUS	3,83	-0,23	4,03	-1,27	4,06
ESTONIA	4,4	0,2	5,43	0	4,2
FINLAND	3	0,97	3,57	0,97	2,03
GREECE	2,63	-1,83	4,43	-2,2	4,46
IRELAND	1,63	0,1	2,4	0,1	1,53

LATVIA	4,06	0,63	4,6	-0,2	3,43
LITHUANIA	4,03	0,2	4,73	0,2	3,83
LUXEMBOURG	3,73	-0,1	3,9	-0,1	3,83
MALTA	1,9	0,6	3,93	0,53	1,3
PORTUGAL	3,8	-0,03	3,8	-0,27	3,83
SLOVAKIA	4,67	0	4,67	-0,13	4,67
SLOVENIA	2,6	0	3,13	0	2,6

An analysis of the data in Table 15 reveals that in this period, inflation rates across the eurozone countries differed less from each other than in the 2008 global financial crisis period. For example, between 2011 and 2014, the highest inflation rates in Germany and France, the two largest economies and industrialized countries of the European Union, were 2,63, whereas the highest inflation rates in Latvia and Lithuania, the smaller economies, were 4,6 and 4,73, respectively. Over the same period, the minimum inflation rates were closer to each other. In line with these observations, since the difference between inflation before and after the intervention is higher in small-scale economies, it is possible to say that the ECB's monetary policy interventions using the interest rate instrument are more effective in small-scale economies where the inflation rate varies over a wider range.

4.3 An Emprical Analysis of the COVID-19 Period

Table 16: Summary Statistics of The Variables Used For COVID-19 Period

Variable	Obs	Mean	Std. Dev.	Min	Max
Inflation	320	1.499906	1.570526	-2.3	9.4
ECBinterestlag2	320	0	0	0	0
Moneysupplylag2	320	1.30e+07	1021797	1.17e+07	1.49e+07
Population	320	1.73e+07	2.46e+07	467999	8.32e+07
GDPpercapita	320	51389.27	22555.43	26915.6	143467.4
Unemployment	320	7.345281	3.474887	2.9	21

We tested the effects of the ECB interest rate on inflation in the COVID-19 term using this table, which provides a basic summary of our dependent and independent variables. We use all 20 eurozone countries and quarterly data between 2018 and 2021, so we have 320 observations for all our variables. According to the table, our dependent variable inflation has a 1.499906 mean value, which is slightly lower than the inflation target of ECB and a 1.570526 standard deviation. Minimum values and maximum values are -2.3 and 9.4 respectively, for inflation in this period. We can see that inflation took a negative turn during this period due to the impact of the crisis. ECBinterestlag2 is an omitted variable in this regression because it is zero for the whole period. This shows that the ECB could not use its interest rate tools during

this period. Moneysupplylag2 has a 13.000.000 mean value and 1,021,797 standard deviation. Minimum values and maximum values are 11,700,000 and 14,900,00, respectively, for the Moneysupplylag2 in this period. The population has a 17.3 million mean value and a 24.6 million standard deviation. Minimum values and maximum values are 467999 and 83,2 million, respectively, for the population in this period. It demonstrates a significant difference in population between the eurozone's smallest and largest countries. GDPpercapita has 51389.27 mean value and 22555.43 standart deviation. Minimum values and maximum values are 26915.6 and 143467.4 respectively, for the GDPpercapita in this period. We can say that there is a big gap between the eurozone countries in terms of their wealth conditions. The mean value of unemployment is 7.345281, and the standard deviation is 3.474887. Minimum values and maximum values are 2.9 and 21 respectively, for unemployment in this period. This indicates a significant disparity between their respective job markets.

Table 17: Pairwise Correlation Matrix For COVID-19 Period (2018-2021)

	ECBinterest lag2	**Moneysuppl y lag2**	**Population**	**GDP percapita**	**Unemploy-ment**
ECBinterestlag2	1				
Moneysupplylag2	-	1			
Population	-	0.0009	1		
GDPpercapita	-	0.1328	-0.038	1	
Unemployment	-	-0.0162	0.1443	-0.3258	1

The table that is given above shows an interactive correlation between our independent variables that are used in our model. ECB interestratelag2 is omitted because it is zero during the whole period. According to this matrix, the correlation among the other independent variables is weak or negligible.

Table 18: Hausman Test For The COVID-19 Period

Hausman test	
	Coef.
Chi-square test value	57.81
P - value	0.0000

In deciding whether fixed effects or random effects is better suited for our panel data study, we applied the Hausman test. According to the test results, the chi-square value of 57.81, combined with a p-value of 0.0000 strongly indicates that the fixed effects model is more appropriate for our models. This means that the difference between the fixed effects model and

the random effects model is statistically significant, and the fixed effects model should be preferred. In other words, the unique errors are correlated with the regressors, and the fixed effects model will provide more reliable and consistent estimates.

Table 19: Panel Regression Results For The COVID-19 Period

VARIABLES	(1) Inflation
o.ECBinterestlag2	-
Moneysupplylag2	-8.96e-08
	(9.94e-08)
Population	7.78e-08
	(4.90e-07)
GDPpercapita	0.000136***
	(2.40e-05)
Unemployment	-0.519***
	(0.0851)
Constant	-1.840
	(8.335)
Observations	320
Number of country numeric	20
R-squared	0.252

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The table presented above shows the regression results of the COVID-19 period in the Eurozone, which were calculated using the fixed effects regression model. The main target of this test is to discover the effects of ECB interest rate changes on inflation in the eurozone area, which is mentioned in Hypothesis 3. We consider all 20 Eurozone countries and use 16 consecutive quarters as the time period; therefore, we have 320 observations in total. According to their p-values, only two variables are statistically significant at the 5% level. The first is GDP per capita, which has a 0.0001357 coefficient. This means that for every one unit increase in GDP per capita, inflation is expected to increase by 0.0001357 units. The second one is unemployment, which has a -0.519212 coefficient. The unemployment coefficient of -0.519212 suggests that a one-unit increase in the unemployment rate is associated with a 0.519212 unit decrease in inflation. Our other independent variables, Moneysupplylag2 and Population, are statistically not significant.

Lastly, ECBinterestlag2 is omitted for this regression analysis because the ECB interest rate was zero and stable during the COVID-19 period. When COVID-19 became a pandemic all around the world and affected the economy, there was disinflation pressure on European economies, so the ECB policy rate was already zero and close to zero lower bond. This means that there wasn't a chance to decrease the interest rate any more by increasing demand to stimulate the economy. Therefore, the interest rate tool was not a convenient tool for the ECB at that time, and this led the ECB to modify its policies and start to rely on unconventional monetary policy tools, including asset purchasing programs and providing liquidity. Considering all these issues we have mentioned, it is not possible to mention the effects of the ECB's interest rate policy on inflation in the euro area for the COVID-19 crisis term.

Table 20: Inflation in Eurozone Countries Between 2018-2021

Countries	Inflation Before First Ecb Intervention	Inflation After Last Ecb Intervention	Max Inflation (2018-2021)	Min Inflation (2018-2021)	Difference Between Inflation Before And After The Intervention
FRANCE	-	-	3,33	0,1	-
GERMANY	-	-	5,43	-0,63	-
ITALY	-	-	3,77	-0,4	-
NETHERLANDS	-	-	5,33	0,97	-
SPAIN	-	-	5,83	-0,77	-
AUSTRIA	-	-	3,9	1,07	-
BELGIUM	-	-	6,37	0	-
CROATIA	-	-	4,6	-0,43	-
CYPRUS	-	-	4,63	-2,3	-
ESTONIA	-	-	9,13	-1,43	-
FINLAND	-	-	3,17	-0,1	-
GREECE	-	-	3,73	-2,23	-
IRELAND	-	-	5,4	-1,17	-
LATVIA	-	-	7,1	-0,7	-
LITHUANIA	-	-	9,4	0,27	-
LUXEMBOURG	-	-	5,67	-0,93	-
MALTA	-	-	2,33	0,13	-
PORTUGAL	-	-	2,4	-0,43	-
SLOVAKIA	-	-	4,77	1,03	-
SLOVENIA	-	-	4,5	-1,17	-

Since Europe was already under deflationary pressure during the Covid-19 crisis, and since the ECB's interest rate was zero and there was no possibility to reduce it further in order to increase demand and raise inflation, the ECB did not intervene using the interest rate

instrument during this period. Moreover, although there is not as significant a difference between the inflation rates of large industrialized countries and small-scale economies as there was during the 2008 global financial crisis and the European debt crisis, it is still possible to say that industrialized and large-scale economies are slightly less affected by the problem of high inflation.

4.4 An Emprical Analysis of the Energy Crisis That Emerged After Russia's Invasion of Ukraine

Table 21: Summary Statistics of The Variables Used For The Energy Crisis Period in The Euro Area

Variable	Obs	Mean	Std. Dev.	Min	Max
Inflation	240	6.298708	4.761121	-2.1	24.16
ECBinterestlag2	240	.735	1.247548	0	3.67
Moneysupplylag2	240	1.54e+07	696230.9	1.41e+07	1.61e+07
Population	240	1.74e+07	2.48e+07	515332	8.47e+07
GDPpercapita	240	60482.79	27416.27	31085.4	148226.7
Unemployment	240	6.503	2.70419	2.5	16.43

We used this table to test the impact of the ECB interest rate on inflation during the energy crisis in the euro area, providing a basic summary of our dependent and independent variables. We use all 20 eurozone countries and quarterly data between 2021 and 2023, so we have 240 observations for all our variables. According to the table, our dependent variable inflation has a 6.298708 mean value, which is quite higher than the inflation target of the ECB, and a 4.761121 standard deviation. Minimum values and maximum values are -2.1 and 24.16 respectively, for the inflation in this period. We can see that inflation took negative and also too high values in this period due to the impact of the increase in energy prices. ECBinterestlag2 has a 0.735 mean value and a 1.247548 standard deviation. Minimum values and maximum values are 0 and 3.67 respectively, for the ECBinterestlag2 in this period. This shows that the ECB used their interest rate tools in this period in a wide range to decrease inflation. Moneysupplylag2 has a 15.4 million mean value and a 696230.9 standard deviation. Minimum values and maximum values are 14.1 million and 16.1 million, respectively, for the Moneysupplylag2 in this period. The population has a 17.4 million mean value and a 24.8 million standard deviation. Minimum values and maximum values are 515332 and 84,7 million, respectively, for the population in this period. It demonstrates a significant difference in population between the eurozone's smallest and largest countries. GDP per capita has a 60482.79 mean value and a 27416.27 standard deviation. Minimum values and maximum values are 31085.4 and 148226.7 respectively, for the GDPpercapita in this period. We can say that there is a big gap between the eurozone countries in terms of their wealth conditions. The mean value

of unemployment is 6.503, and the standard deviation is 2.70419. The minimum and maximum values for unemployment during this period are 2.5 and 16.43, respectively. This indicates a significant disparity between their respective job markets.

Table 22: Pairwise Correlation Matrix For The Energy Crisis Period (2021-2023)

	ECBinterest lag2	**Moneysupply lag2**	**Population**	**GDP percapita**	**Unemploy-ment**
ECBinterestlag2	1				
Moneysupplylag2	0.5795	1			
Population	0.0024	0.0027	1		
GDPpercapita	0.0670	0.1217	-0.0567	1	
Unemployment	-0.1010	-0.2047	0.1579	-0.3560	1

The table that is given above shows an interactive correlation between the independent variables used in our model. According to this matrix, there is no strong correlation that is bigger than 0,7 or smaller than -0,7. The strongest correlation has a 0.5795 coefficient between ECBinterestlag2 and Moneysupplylag2, but it is still smaller than 0.7, so it does not count as a strong correlation. Most other correlations among the independent variables are weak or negligible

Table 23: Hausman Test For The Energy Crisis Period

Hausman test	
	Coef.
Chi-square test value	2.16
P - value	0.5400

In deciding whether fixed effects or random effects is better suited for our panel data study, we applied the Hausman test. According to the test results, the chi-square value of 2.16 combined with a p-value of 0.5400 strongly indicates that the difference between the fixed effects model and random effects model is not statistically significant and the random effects model should be preferred based on failing to reject the null hypothesis. So we will use a random effects model to analyze the European debt crisis period.

Table 24: Panel Regression Results of The Energy Crisis Period

VARIABLES	(1) Inflation
ECBinterestlag2	-2.671***
	(0.156)
Moneysupplylag2	6.06e-06***
	(3.13e-07)
Population	-2.10e-08
	(1.93e-08)
GDPpercapita	-2.99e-05*
	(1.80e-05)
Unemployment	-0.228
	(0.168)
Constant	-81.16***
	(5.306)
Observations	240
Number of country_numeric	20

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The table that is given above includes the regression results of the energy crisis, which were calculated using the random effects regression model. The main target of this test is to discover the effects of ECB interest rate changes on inflation in the eurozone area, which is mentioned in Hypothesis 4. We consider all 20 Eurozone countries and use 12 consecutive quarters as the time period, therefore, we have 240 observations in total. We are trying to measure the effects of the ECB interest rate on inflation, so variability between countries is not important, which means that the important R-sq value is within R-sq value for us. Our within R-sq value is 0.7020 which means that 70.2% of the variability in the dependent variable (inflation) within each country is explained by the model. The Wald Chi-square statistic of 516.72 with a p-value of 0.0000 indicates that the model is highly statistically significant, meaning that the explanatory variables jointly have a significant effect on inflation. According to their p-values, our independent variables ECBinterestlag2 and Moneysupplylag2 are statistically significant at the 5% level, although GDP per capita is not significant at the 5% level; it is significant at the 10% level. However, at the 5% and 10% levels, population and unemployment are statistically not significant. ECB interestlag2 has a negative coefficient of -2.670624, which means that for each one-unit increase in the lagged ECB interest rate, inflation decreases by approximately 2.67 units, holding other factors constant. This strong negative effect suggests that higher ECB interest rates tend to reduce inflation. Unlike the 2008 global crisis and the European debt crisis period, this time the ECB interest rate has a negative coefficient that is expected according to

the economic laws. So we can say that, in the face of double-digit inflation in many euro area countries, the European Central Bank's raising the interest rate from zero to 4.5 percentage points in a short period of one year has been extremely effective on inflation and that the ECB has been successful in approaching its target inflation rate. Moneysupplylag 2 has a 6.06 coefficient, which indicates a significant positive relationship between the money supply (lagged by two periods) and inflation. A one-unit decrease in the lagged money supply would result in a 6.06 unit decrease in inflation, holding other factors constant. We can easily say that the money supply has been an effective monetary policy tool used effectively by the European Central Bank against the problem of high inflation in this period and has provided significant benefits in approaching the target inflation rate.

Table 25: Inflation in Eurozone Countries Between 2021-2023

Countries	Inflation Before First Ecb Intervention (2022-Q3)	Inflation After Last Ecb Intervention (2023-Q4)	Max Inflation (2021-2023)	Min Inflation (2021-2023)	Difference Between Inflation Before And After The Intervention
FRANCE	6,53	4,17	7	1	2,36
GERMANY	9,4	3	10,83	1,73	6,4
ITALY	8,97	0,97	12,5	0,77	8
NETHERLANDS	14,13	0,5	14,13	0,5	13,63
SPAIN	10,07	3,37	10,07	0,5	6,7
AUSTRIA	9,9	5,17	11,1	1,5	4,73
BELGIUM	11	-0,67	11,26	-0,67	11,67
CROATIA	12,63	5,87	12,8	0,8	6,76
CYPRUS	9,73	2,63	9,73	-0,46	7,1
ESTONIA	24,16	4,5	24,47	0,57	19,66
FINLAND	8,1	1,47	8,77	1,1	6,63
GREECE	11,5	3,47	11,53	-2,1	8,03
IRELAND	9,07	3,1	9,07	-0,13	5,97
LATVIA	21,57	1,43	21,57	-0,13	20,14
LITHUANIA	21,5	2,33	21,5	0,73	19,17
LUXEMBOURG	8,9	2,47	9,5	1,03	6,43
MALTA	7,07	3,93	7,3	0,13	3,14
PORTUGAL	9,5	2,43	10,2	-0,07	7,07
SLOVAKIA	13,27	7,1	15,1	1,03	6,17
SLOVENIA	11,27	4,94	11,27	-0,63	6,33

An analysis of the data in Table 25 reveals that in this period, inflation rates across the eurozone countries differed way more from each other than in the other crisis periods. For

example, between 2021 and 2023, the highest inflation rates in Germany and France, the two largest economies and industrialized countries of the European Union, were 10,83 and 7, respectively, whereas the highest inflation rates in Latvia and Lithuania, the smaller economies, were 21,57 and 21,5, respectively. However, in other small economies, Malta and Cyprus had 7,3, and 9,73% inflation rates, respectively, which are lower than Germany. Therefore, while it is possible to argue that industrialized and large-scale economies were less susceptible to high inflation during this period than small-scale countries, this difference is not as pronounced as it was in the first three crisis periods we examined. The reasons for this are that industrialized and highly populated countries have higher energy needs and that rising energy prices and dependence on natural gas imported from Russia have led to significant increases in prices in industrialized countries. Over the same period, the minimum inflation rates were closer to each other. Last but not least, it is possible to say that the ECB's monetary policy interventions using the interest rate instrument are more effective in economies where the inflation rate varies over a wider range.

5. CONCLUSION

5.1 Discussion and Conclusion

This research study aims at identifying the crisis periods in the Euro zone by using the major deviations from the ECB's inflation target and seeing whether the ECB's interventions using the interest rate instrument were successful in achieving the ECB's target inflation rate of 2% in four different crisis periods with different dynamics. We have used all 20 eurozone countries to get more accurate results. We have collected 20 years of inflation, unemployment, GDP per capita, population, money supply, and ECB interest rate data between 2004 and 2023 for countries in the eurozone using the World Bank, IMF, and ECB databases. Additionally, since it may take time to see the effects of the increase in interest rate and money supply on inflation, we added a lag of 2 quarters to the money supply and ECB interest rate variables to make their effects on inflation more accurate.

Considering the effects of the crises we have identified and the periods in which they occurred, it is evident that they have different dynamics from each other. For this reason, during the 2008 global crisis and the European debt crisis, the European Central Bank's interventions in the economy by using the interest rate instrument did not have the desired effect in the first place. Under normal circumstances, an inverse relationship between inflation and interest rates is expected, i.e., a decrease in the interest rate is expected to lead to an increase in the inflation rate. However, as can be seen from the regression results in Table 9 and Table 14, our ECB interestlag2 variable has a positive coefficient for these periods, but this coefficient gradually decreases as the lag time increases. Therefore, it is possible to say that the monetary policy implemented by the ECB using the interest rate instrument was not fully effective in these two crisis periods, and even if the decline in interest rates slowed down the rate of decline in inflation, it was not enough to raise inflation and bring it closer to the ECB's target inflation rate of 2. For this reason, it can be said that we can not reject our H1 and H2 hypotheses.

The crisis caused by COVID-19, which turned into a global pandemic and affected the economies of European countries after raising in China, had a quite different dynamic than the other crisis period, which we detected in our research. At that time, the Eurozone was already dealing with a low inflation problem and the risk of deflation. Because of that, ECB interest rates have already been too low for too long. When we look at the period from the beginning of 2018 to the end of 2021 to analyze the data to test the effects of the crisis caused by the pandemic, it would be correct to say that the European Central Bank’s Main Refinancing Operations

Interest Rate was zero during this four-year period. It means that the European Central Bank's interventions using the interest rate instrument during the COVID-19 crisis did not have a positive and significant effect on the ECB's achievement of its inflation target. Hence, we cannot reject our H3 hypothesis.

In the aftermath of the Russian invasion of Ukraine, inflation in Europe skyrocketed and reached double-digit figures in many Eurozone countries due to the increase in energy prices and the shortages in the supply of food products. As many European countries are dependent on natural gas imported from Russia for their energy supply, the rise in inflation has been sharp. In response to this situation, the ECB took swift action and gradually increased the Main Refinancing Operations Interest Rate from zero to 4.5, which led to a rapid decline in inflation rates in the eurozone countries. Taking the Netherlands as an example, the inflation rate, which was 14.13% in the 3rd quarter of 2022 (ECB interest rate 0.5 in this quarter), declined rapidly as a result of the gradual interest rate increase and was reduced to 0.5% in the last quarter of 2023 (ECB interest rate 4.5 in this quarter). The fact that the ECB interestlag2 variable has a coefficient of -2.67 in Table 24 is an indication that the ECB interest rate was used as an effective monetary policy tool in this period and successful results were achieved, which is different from the other 3 crisis periods that we have identified. According to this coefficient, each 1 unit increase in the interest rate indicates a decrease of -2.67 percentage points in the inflation rate. Although supported by other monetary policy instruments, compared to other crisis periods, in general, the European Central Bank's interventions using the interest rate instrument during the energy crisis have a positive and significant effect on the ECB's achievement of its inflation target; therefore, we can reject our H4 hypothesis.

In conclusion, we can say that while the interest rate instrument is a very important conventional monetary policy used by the ECB, it is not always sufficient on its own. As can be seen from our analysis, during the 2008 global crisis and the European debt crisis, it could not fully cure the decline in inflation rates but only slowed down the rate of decline, while in the crisis due to COVID-19, it was not effective at all, as interest rates were already zero and could not be further reduced. In the energy crisis following the Russian invasion of Ukraine, the ECB's interest rate hikes in the face of high inflation were very effective and succeeded in approaching the target inflation rate set by the ECB in a short period of time. As a result of these analyses, it can be concluded that the interest rate is still an effective monetary policy tool, but given that each crisis has different dynamics, it can be said that when this policy tool is insufficient, it will

continue to contribute to the achievement of the ECB's policy objectives by continuing to be supported by non-traditional monetary policy tools.

5.2 Limitation

As we have already noted in our study, there are many conventional and unconventional monetary policy instruments that the European Central Bank can use to achieve its target inflation rate. The impact of other monetary policy instruments, typically used to support the interest rate instrument, on the achievement of the ECB's inflation target is not considered in this study. Future research could look into the effects of other monetary policy tools, especially quantitative easing, in addition to interest rate instruments. Finally, since the effects of the Russian invasion of Ukraine are still continuing, albeit partially, as of the date of this study, future studies will be able to obtain more reliable results by using data covering a longer period of time, especially in terms of the crisis we test in our fourth hypothesis, which we call the energy crisis.

References

Aguilar, P., Arce, Ó., Hurtado, S., Martínez-Martín, J., Nuño, G., & Thomas, C. (2020). The ECB Monetary Policy Response to the COVID-19 Crisis. Documentos Ocasionales N.o 2026. 9-25.

Assaf, R., Gupta, D., & Kumar, R. (2023). The price of war: Effect of the Russia-Ukraine war on the global financial market. The Journal of Economic Asymmetries, 28, e00328. https://doi.org/10.1016/j.jeca.2023.e00328

Aharon, D. Y., Aziz, M. I. A. A., & Nor, S. M. (2023). Cross-country study of the linkages between COVID-19, oil prices, and inflation in the G7 countries. *Finance Research Letters, 57*, 104172. https://doi.org/10.1016/j.frl.2023.104172

Banco de España. (2021). How do central banks identify risks? A survey of indicators. Documentos Ocasionales, 2125. Retrieved from Banco de España Repository (BDE Repository) (BDE).

Beirne, J., & Fratzscher, M. (2013). The Pricing of Sovereign Risk and Contagion during the European Sovereign Debt Crisis. Journal of International Money and Finance, 34, 60-82.

Benigno, P., Canofari, P., Di Bartolomeo, G., & Messori, M. (2022). The European Monetary Policy Responses During the Pandemic Crisis. *Open Economies Review, 33*(4), 657-675. https://doi.org/10.1007/s11079-022-09665-7

Benigno, P., Canofari, P., Di Bartolomeo, G., & Messori, M. (2023). The ECB's new inflation target from a short- and long-term perspective. Journal of Policy Modeling, 45(2), 286-304. https://doi.org/10.1016/j.jpolmod.2023.03.004

Blot, C., Creel, J., Hubert, P. (2019). Thoughts on a Review of the ECB's Monetary Policy Strategy. In-depth analysis requested by the ECON committee, Monetary Dialogue Papers, December 2019. European Parliament, Policy Department for Economic, Scientific and Quality of Life Policies. 6-9. Retrieved from http://www.europarl.europa.eu/supporting-analyses

Braun, B. (2015). Preparedness, Crisis Management and Policy Change: The Euro Area at the Critical Juncture of 2008–2013. The British Journal of Politics and International Relations, 17(3), 419-441. https://doi.org/10.1111/1467-856X.12026

Colgan, J. D., Gard-Murray, A. S., & Hinthorn, M. (2023). Quantifying the value of energy security: How Russia's invasion of Ukraine exploded Europe's fossil fuel costs. *Energy Research & Social Science, 103*, 103201. https://doi.org/10.1016/j.erss.2023.103201

Dawood, M. H. A. K. (2016). The challenge of predicting financial crises: Modelling and evaluating early warning systems (Ph.D. thesis). University of Birmingham.

European Central Bank. (2010, October). Monthly Bulletin, October 2010. Retrieved from https://www.ecb.europa.eu/pub/pdf/mobu/mb201010en.pdf

Fumagalli, A. ve Sandro, M. (2012). Crisis in the Global Economy: Financial Markets, Social Struggles, and New Political Scenarios. Semiotext(e)

Gomes, S., Iskrev, N., & Ribeiro, P. P. (2021). Euro area inflation expectations during the COVID-19 pandemic. *Banco de Portugal, UECE/REM Banco de Portugal*. 21-22.

Gorton, G. (2018). The anatomy of a crisis: The causes and consequences of surging financial instability. European Financial Management, 24(2), 207-237. https://doi.org/10.1111/eufm.12130

Greenwood, R., Hanson, S. G., Shleifer, A., & Sørensen, J. A. (2022). Predictable Financial Crises. *Journal of Finance, The, 77*(2), 863-921. https://doi.org/10.1111/jofi.13105

Haas, Jacob and Neely, Christopher J. and Emmons, William R., Responses of International Central Banks to the Covid-19 Crisis (October 1, 2020). FRB of St. Louis Working Paper No. Forthcoming, Available at

SSRN: https://ssrn.com/abstract=3736262 or http://dx.doi.org/10.20955/r.102.339-84

HARTMANN, P., & SMETS, F. (2018). The European Central Bank's Monetary Policy during Its First 20 Years. Brookings Papers on Economic Activity, 1–118. https://www.jstor.org/stable/26743874

Hobelsberger, K., Kok Sørensen, C., & Mongelli, F. P. (2022). A tale of three crises: Synergies between ECB tasks. ECB Occasional Paper No. 305. European Central Bank (ECB), Frankfurt a. M.

HODSON, D. and QUAGLIA, L. (2009), European Perspectives on the Global Financial Crisis: Introduction†. JCMS: Journal of Common Market Studies, 47: 939-953. https://doi.org/10.1111/j.1468-5965.2009.02029.x

Liotti, G., Canale, R.R. Trust in the European Union project and the role of ECB. Econ Polit 38, 461–482 (2021). https://doi.org/10.1007/s40888-021-00229-5

Morelli, P., & Seghezza, E. (2021). Why was the ECB's reaction to Covid-19 crisis faster than after the 2008 financial crash? *Journal of Policy Modeling*, *43*(1), 1-14. https://doi.org/10.1016/j.jpolmod.2020.12.002.

Niinimäki, J., & Välimäki, T. (2023, September 7). Back to the old normal? Monetary policy implementation in a landscape of rising interest rates and a shrinking Eurosystem balance sheet. BANK OF FINLAND ARTICLES ON THE ECONOMY. https://www.bofbulletin.fi/en/2023/3/back-to-the-old-normal-monetary-policy-implementation-in-a-landscape-of-rising-interest-rates-and-a-shrinking-eurosystem-balance-sheet/

Orphanides, A., & Reichlin, L. (2023, Mart). Rusya-Ukrayna savaşının enflasyona etkisi. NBER Çalışma Makalesi No. 30135. https://www.nber.org/papers/w30135

Pronobis, M. (2014). Is Monetary Policy of ECB the Right Response to the Eurozone Crisis? Procedia- Social and Behavioral Sciences, 156, 398-403. https://doi.org/10.1016/j.sbspro.2014.11.210.

Reinhart, C. M., & Rogoff, K. S. (2009). This Time is Different: Eight Centuries of Financial Folly. Princeton University Press. xxvi-xxvii.

Taskovski, F., & Paceskoski, V. (2023). THE INFLUENCE OF THE RUSSIAN-UKRAINIAN CONFLICT ON THE EURO. KNOWLEDGE-International Journal, 61(1), 135-140.

Taylor, John B., The Financial Crisis and the Policy Responses: An Empirical Analysis of What Went Wrong (January 1, 2009). Rock Center for Corporate Governance Working Paper No. 30, NBER Working Paper No. w14631 , Available at SSRN: https://ssrn.com/abstract=1341170 or http://dx.doi.org/10.2139/ssrn.1341170

Tetteh, B., & Ntsiful, E. (2023). A comparative analysis of the performances of macroeconomic indicators during the Global Financial Crisis, COVID-19 Pandemic, and the Russia-Ukraine War: The Ghanaian case. *Research in Globalization, 7*, 100174. https://doi.org/10.1016/j.resglo.2023.100174

Trichet, Jean-Claude. (2010). State of the union: the financial crisis and the ecb's response between 2007 and 2009. Journal of Common Market Studies, 48(Annual Review), 7-20

Zdeněk Pavlík,. (2012). "The Monetary Policy of the ECB in the Time of Crisis: The Current Empirical Analysis," Současná Evropa, Prague University of Economics and Business, vol. 2012(1), pages 3-28.